

# WHAT IS SCIENCE?

Karen Haydock

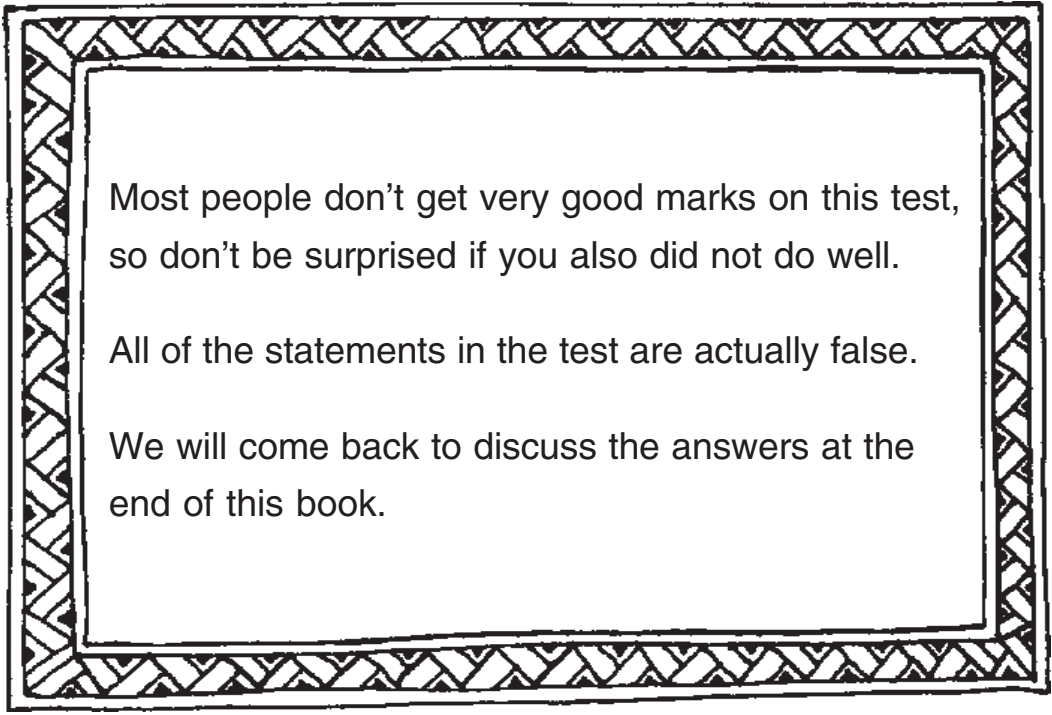
(partially illustrated rough draft)



You must have studied science for a number of years in school.  
But do you really know what science is? Take this test and find out.

## TRUE OR FALSE?

1. Plants get big by taking food from the soil through their roots.
2. Burning is a process in which matter is destroyed.
3. The sun rises in the east.
4. Blood is red.
5. Electrical current is used up in lighting a bulb.
6. Heavier bodies fall faster than light ones.
7. Cavemen fought dinosaurs.



Most people don't get very good marks on this test,  
so don't be surprised if you also did not do well.

All of the statements in the test are actually false.

We will come back to discuss the answers at the  
end of this book.

Now take a look  
at the statements  
on the facing  
page. They are  
all direct quotes  
from science  
textbooks.

Water always flows  
from a higher place  
to a lower place.

Plants get food from the earth and sunlight.  
It is quite easy to tell which things  
have life in them.

Desert plants like the cactus do not have leaves.  
All rocks on the surface of the earth get broken down  
into pebbles, gravel and mud.  
The largest living thing is a tree.  
Water goes up  
the stem to the leaves.

We have  
206 bones  
in our body.  
We cannot see germs.  
We live in a house because it keeps us safe.  
We wear rubber boots when it rains.  
All living things need oxygen.

When we are farther from the sun we have winter.  
There are many danger areas in a house.  
Desert plants have no leaves at all or needle shaped leaves.

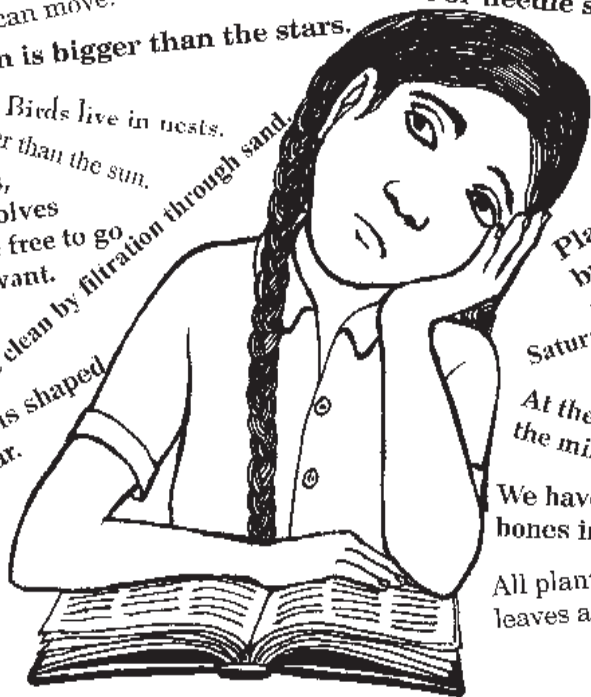
All animals can move.  
The sun is bigger than the stars.

Birds live in nests.  
Stars are bigger than the sun.

Some animals,  
like tigers, wolves  
and foxes are free to go  
where they want.

Blood is red.  
Water can be made clean by filtration through sand.  
The earth is shaped  
like a pear.

The world  
gives us  
all we want.



All plants and  
animals move.

Plants do not eat  
but they make  
their own food.

Saturn has 14 moons.  
The earth  
is shaped  
like a ball.

At the age of six  
the milk teeth fall out.

We have 212  
bones in our body.

All plants have stems,  
leaves and roots.

How many contradictory  
or wrong statements can  
you find here?

How can it be that in one  
textbook you read that  
“water always flows from  
a higher place to a lower  
place”, but then, in  
another chapter you read  
that “water goes up the  
stem to the leaves”?

Is the earth shaped like a  
pear or a ball?

Are tigers, wolves and  
foxes free to go where  
they like?

Does a house “keep us  
safe” or are there “many  
danger areas in a  
house”?

# WHAT'S WRONG?

Why do we have difficulty answering questions in science?

Why do we find so many 'wrong' statements in science books?

Maybe it is because we are confused about what science is, and about what science tells us about the nature of reality..

Were these just unusually bad textbooks, written by unusually ignorant authors?

No, there is nothing unusual about the books from which these statements were taken. You can pick up any textbook and on almost any page you will find such statements. You can make corrections, and corrections of the corrections, and you will still find 'errors'...

Maybe the problem is that we are expecting a science textbook to be full of the true facts about the world.

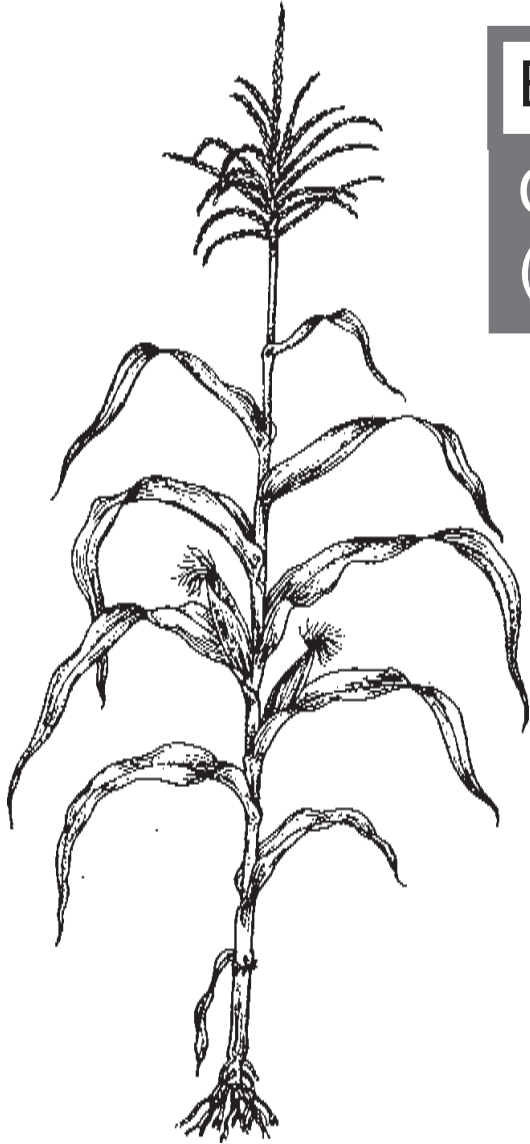
## Is science a collection of facts?



**NO!**

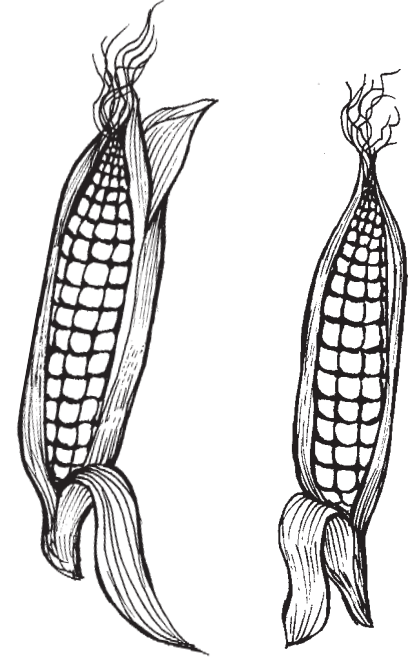
Science is a process - method of **questioning...**

and finding answers to questions by observing, hypothesizing, experimenting, analysing results, making conclusions, and re-questioning.



## EXAMPLE 1:

### CORN (MAIZE)



## QUESTION:

Why are some corncobs larger than others?

Some would say:

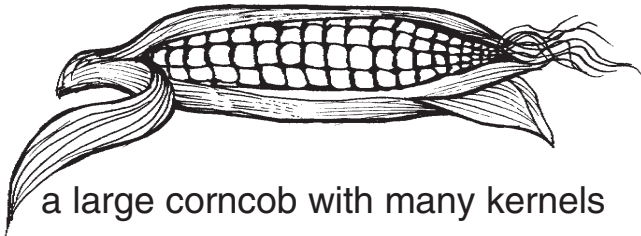
God knows.

We do not know, and we cannot know.

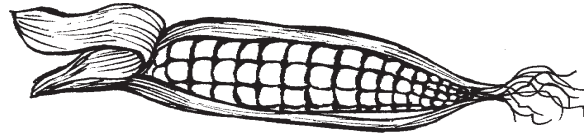
Others say:

Let's use science to find out.

## OBSERVE:



a large corncob with many kernels



a small corncob with fewer kernels

## QUESTION:

Why are some corncobs larger?

Why is this an important question to raise?

## HYPOTHESISE:

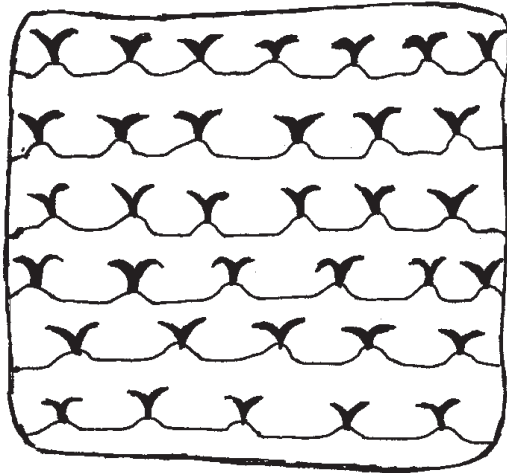
Maybe the seed from which the plant grows determines the size of the corncob it produces.



Do the seeds look different? If they don't **look** different, how can they be different?

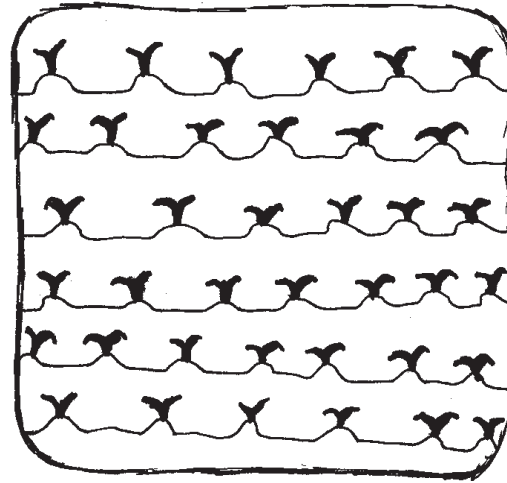


## TEST:



We plant seeds from  
large corn cobs in plot A.

Harvest from plot A:  
mostly large corn cobs



We plant seeds from  
small corn cobs in plot B.

Harvest from plot B  
Mostly small corn cobs



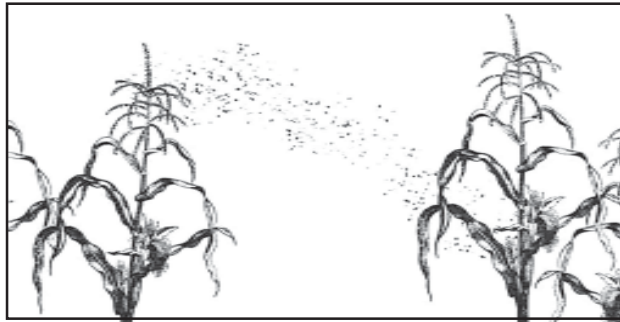
Is this the best  
design for the  
experiment?  
Why do we  
need to have  
plot B? Why  
can't we  
answer our  
question just by  
planting seeds  
from large  
corn cobs in  
plot A?

## CONCLUDE:

Yes, the seed seems to have determined the size of the corncob.

## RE-QUESTION:

But, why did the plants at the edge of the field produce both large and small corncobs?



We can understand corn size as being solely due to natural forces.

There is no need to believe that things were determined by a god.

We can understand nature. And we can (to some extent) control nature for our benefit.

Thus, people used artificial selection to produce better corn.

Scientists do not understand all the details, but they realise that they can do science in order to find better and better answers to the question.

What are some other factors, besides the seed, that may help determine the quality of a corncob?

# WHICH QUESTIONS?

What are the questions scientists raise?

Which questions are important?

How do questions come to our minds? Do they just appear out of the blue for some mysterious reason that we cannot understand?

Are teachers the ones who think of questions? Do textbook writers and question paper writers decide which questions are important?

Perhaps you have been confronted by the question, "What is photosynthesis?" Why has this question been asked? Is it more important than other questions? Why? Is it useful or necessary to know what photosynthesis is? Is it necessary just so that you can score high marks on your exam? And is scoring high marks necessary so that you can become a doctor or an engineer or so that you can get a good job and make a lot of money? Is that the purpose? Is this question there just because it is a difficult question that will make exams difficult - because the purpose of exams is to select just a very few people to become members of an elite class?

Why do people do science?

...to understand the world.

Why do we want to understand the world?

...to change it - to make it a better place.

# HYPOTHESES

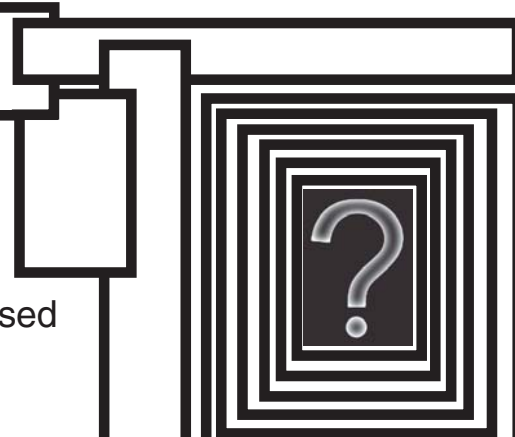
A hypothesis is not just a wild guess that suddenly enters one's mind for no reason.

It is part of the continuous process of science, based on past observations, questions, experiments, evidence, and analysis.

A hypothesis is proposed in order to be tested - at first it is not clear whether it is true or false.

Thus an unproven hypothesis cannot be used as evidence in order to prove a particular point.

Sometimes we do science without having a very clear or specific hypothesis in mind. As we observe, test, experiment, and analyse, we develop conclusions, theories, and hypotheses for further testing..



The belief that “God did it” is not a good scientific hypothesis, because it is not based on material evidence.

Now let's look at an example in the social sciences.

## EXAMPLE 2



I work all day. I don't have  
enough food to eat.  
The landowner eats well.

**QUESTION:**

**WHY ARE THERE RICH  
AND POOR?**

Some would say:

It is the will of God.

or:

It is because some people are careful and farsighted, others are thriftless, lazy and stupid.

It is 'human nature'.

This is the way things are. There is nothing we can do about it.

However, let's use the scientific approach...



Using science, we can observe different societies, ask questions, and try to figure out the material reasons.

## QUESTION:

Why are there rich and poor?

## HYPOTHESIS:

It is due to the economic structure of society.





## EVIDENCE:

Some own the land while the others have to work for them.

After analysing societies in different places and at different times, we see that the people are part of a certain economic system, in this case, it is capitalism.

## CONCLUSION:

However hard they work, those who do not own the land will remain poor. The owners will grow rich due to the labour of the poor.

Taking this approach, we also come to see that things do not have to be like this. Better systems are possible.



So, we see that there are two very different ways of thinking about the world:

## MATERIALISM

The world of science, nature.

Matter is basic.

Ideas cannot exist without matter.

Mental processes are physical processes of the brain.

What do we mean by 'matter'?

In physics, 'matter' is loosely defined as anything made of elementary particles.

Matter and energy are interchangeable:

$$E = mc^2$$

...so we really mean matter or energy...  
or we could say, 'the physical world'.

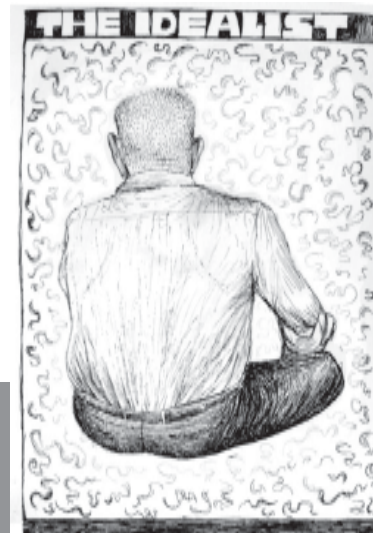
## IDEALISM

The world of gods, ideas, the soul.

Ideas are basic.

Matter is derivative from mind.

Ultimately, matter is not real.



Nowadays, it is rare to find people thinking as pure idealists - claiming that we are just imagining the existence of the physical world. Most people are either materialists or dualists.

## DUALISM

A belief in two worlds:

1. The world of PHYSICAL STATES
2. The world of MENTAL STATES (IDEAS, SPIRITS)

A person is

a physical body + a mind (or soul)

Note that here we are distinguishing between the **brain**, which is part of the physical body, and the **mind**, which is our consciousness.



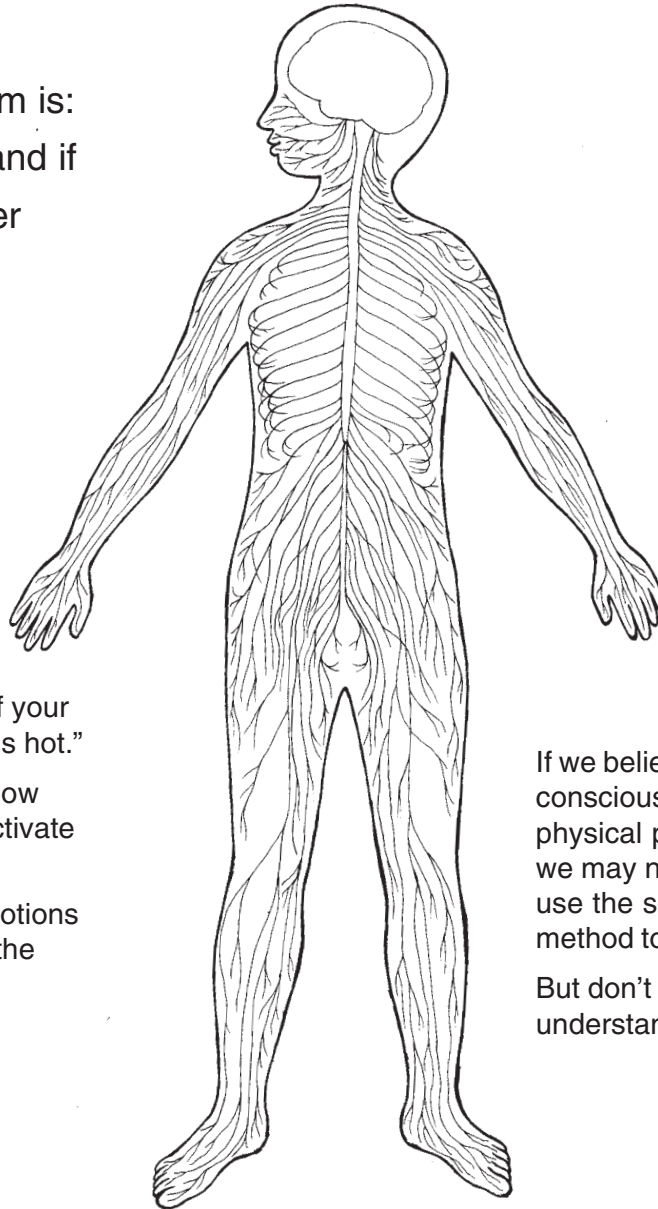
But the major problem with dualism is: if these two states are separate, and if one is totally material and the other totally immaterial, how can they interact with each other?

And where would the interaction take place?

Obviously, the mind does consciously direct the body at times - for example when you think, "Now I will raise my hand", and then you do raise your hand. The body also directs the mind - for example, if your hand comes close to fire, you will think, "it is hot."

But if thinking has no physical properties, how can it have a physical effect? How can it activate a neuron?

We can cause changes in thinking and emotions by physically and chemically manipulating the brain. How could this happen if the mind is separate from the brain?



If we believe that consciousness is not a physical process, then we may not even try to use the scientific method to investigate it.

But don't we need to understand the mind?.

Through scientific investigation, the process by which life evolved from non-life through chemical reactions and physical processes is becoming more and more clear.

As life evolved, consciousness also evolved. As we investigate, we find out more and more about how the nervous system works in simple organisms, and how even human consciousness can be understood in terms of the same basic physical processes organised into very complex systems.



According to some dualists, we can avoid conflict by keeping the two worlds separate:

The physical world is the world of SCIENCE (facts, theories).



The ideal world is the world of RELIGION (ethics, ultimate meaning).

But are these two really separable?

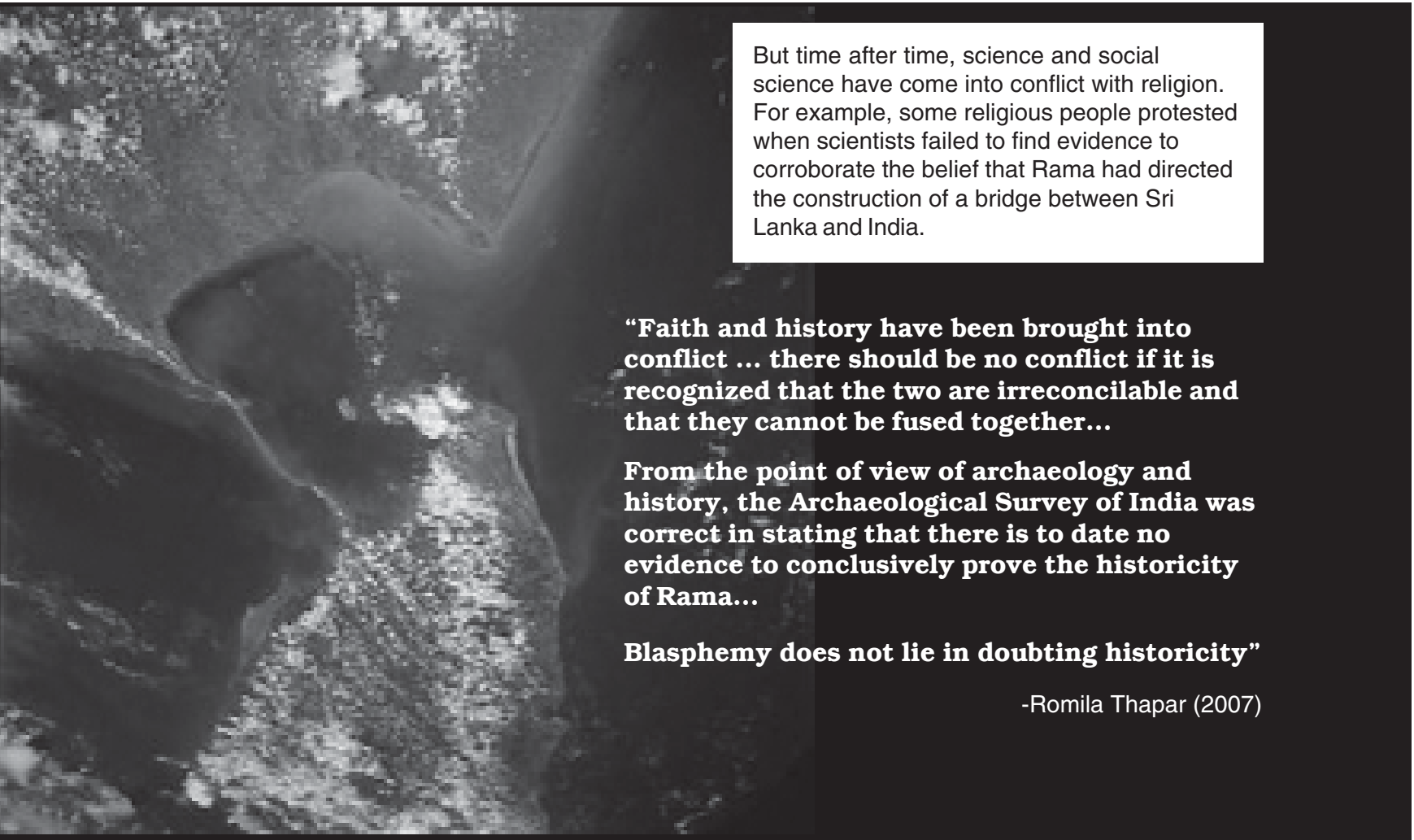
How can we know which questions should be addressed by science and which questions should be restricted to the realm of religion?

For example, why can't we study the scientific basis for fear, happiness, or beauty?

The origin of life and the origin of the universe have previously been thought of as problems of religion - but now they are studied through science.

How can science and religion be kept separate?

Dualists say that religious sentiment belongs in the ideal, abstract world, and cannot be explored through the human senses.



But time after time, science and social science have come into conflict with religion. For example, some religious people protested when scientists failed to find evidence to corroborate the belief that Rama had directed the construction of a bridge between Sri Lanka and India.

**“Faith and history have been brought into conflict ... there should be no conflict if it is recognized that the two are irreconcilable and that they cannot be fused together...”**

**From the point of view of archaeology and history, the Archaeological Survey of India was correct in stating that there is to date no evidence to conclusively prove the historicity of Rama...**

**Blasphemy does not lie in doubting historicity”**

-Romila Thapar (2007)

Science has clashed with religion over questions about the age of the earth, the origin of life, and evolution.

However, the Catholic Church has made efforts to separate religion from science...

**“Some imprudently and indiscreetly hold that evolution ... explains the origin of all things ... Communists gladly subscribe to this opinion so that, when the souls of men have been deprived of every idea of a personal God, they may the more efficaciously defend and propagate their dialectical materialism...**

**The Teaching Authority of the Church does not forbid that, in conformity with the present state of sciences and sacred theology, research and discussions, on the part of men experienced in both fields, take place with regard to the doctrine of evolution, in as far as it enquires into the origin of the human body as coming from pre-existent and living matter - for the Catholic faith obliges us to hold that souls are immediately created by God.”**

- Pope Pius XII (1950)

**“Today ... new knowledge has led to the recognition of the theory of evolution as more than a hypothesis.... it has been proven true; we always celebrate nature’s factuality, and we look forward to interesting discussions of theological implications.”**

- Pope John Paul (1996)



What is the need for religion?

“Religion is regarded by the common people as true, by the wise as false, and by the rulers as useful.”

-Lucius Annaeu Seneca  
(c48 BCE - 65 CE)



“Religion is the sigh of the oppressed creature, the heart of a heartless world, and the soul of soulless conditions. It is the opium of the people.”

“The abolition of religion as the illusory happiness of the people is the demand for their real happiness. To call on them to give up their illusions about their condition is to call on them to give up a condition that requires illusions. The criticism of religion is, therefore, in embryo, the criticism of that vale of tears of which religion is the halo.”

-Karl Marx



# WHO IS WHAT?

## MATERIALISTS

**Lokayata (c600 BCE)**

reality is what we perceive

**Democritus (c460-370 BCE)**

everything is atoms

**LaPlace (1749-1827)**

no need for god

**Hobbes (1588-1679)**

measurable matter is all there is

**Marx (1818-1883)**

historical dialectical materialism

## DUALISTS

**Descartes (1596-1650)**

immaterial minds in material bodies

**Newton (1642-1727)**

a mechanical universe  
regulated by god

**Leibniz (1646-1716)**

mind and body don't really  
interact

## IDEALISTS

**Pythagoras (c582-500 BCE)**

reality is numbers

**Plato (427-347 BCE)**

things are only shadows of  
reality

**Vasubandhu (c400 CE)**

Vijnanavada Buddhism - we  
perceive sensations, not objects

**Berkeley (1685-1753)**

the world is dependent on the  
mind - reality is ideas

Throughout history people have been arguing about materialism vs. idealism.

**Why** are there these different ways of thinking about the world?

What effects do these ways of thinking have on society?

## MATERIALISM

Helps people to question everything.

Helps people to change things.

## IDEALISM

Helps people accept things as they are.

Helps keep people in their places.

Thus, materialism is progressive, and idealism is conservative.

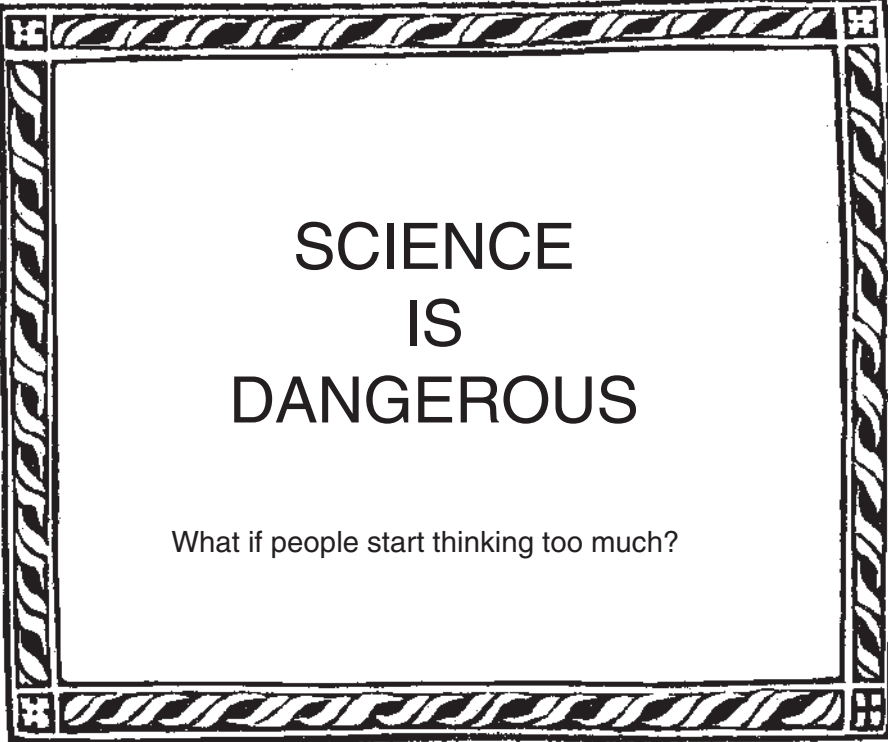
Was idealism designed by those in power in order to keep their subjects in obedience?

Or was it designed simply to make people a little happier?

In feudal times, kings said, "Obey me, I am god." They recorded genealogies to show their lineage leading back all the way to a god.



Even nowadays, rulers say, "Accept things the way they are. Accept your position in the world. Keep working [to make us rich]. You can only pray for something better after death."



# SCIENCE IS DANGEROUS

What if people start thinking too much?

In order to understand the world, we need a system of logical thinking. One system we often use is called

## ARISTOTELIAN LOGIC:

(Aristotle's Metaphysics)

A is A.

A is not non-A

X is either A or non-A, but not both at once.

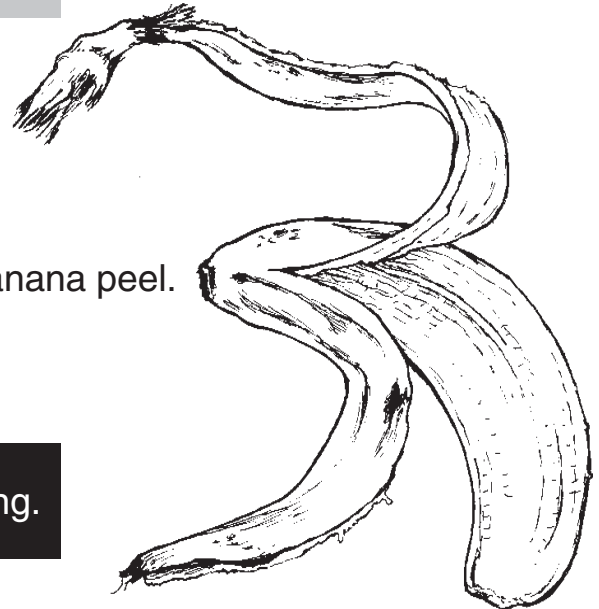


In other words,

a rose is a rose.

A banana peel is a banana peel.

Things are separate, individual, unchanging.



This metaphysical logic sounds like common sense.

But, if we think a little deeper, we find that it misses some basic characteristics of the way things really work. While at times it is useful, at some level, it prevents us from gaining a fundamental understanding.

Things are not so black and white.

Nothing is really so separate, individual, or static.

There is another way of thinking about the world  
that is more useful for getting a deeper,  
scientific understanding.





# SCIENCE

## DIALECTICAL MATERIALISM

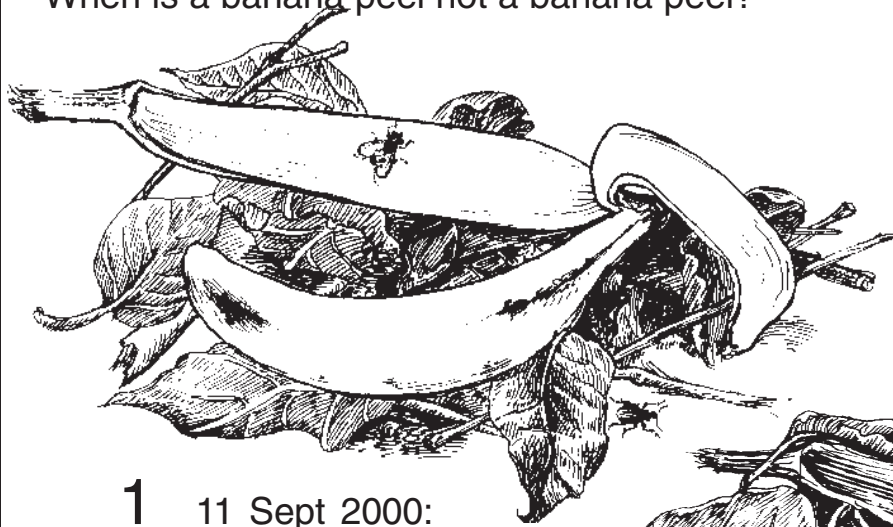
- A is A and also non-A
- Things/processes are interconnected and interdependent
- Things change - from quantitative to qualitative
- Each new thing gets replaced by a newer thing

Let's try to understand what this means...

# A IS A AND ALSO NON-A

Internal contradictions are present in all things/processes.

When is a banana peel not a banana peel?



1 11 Sept 2000:



2 Sept 2000:



3 25 Sept 2000:



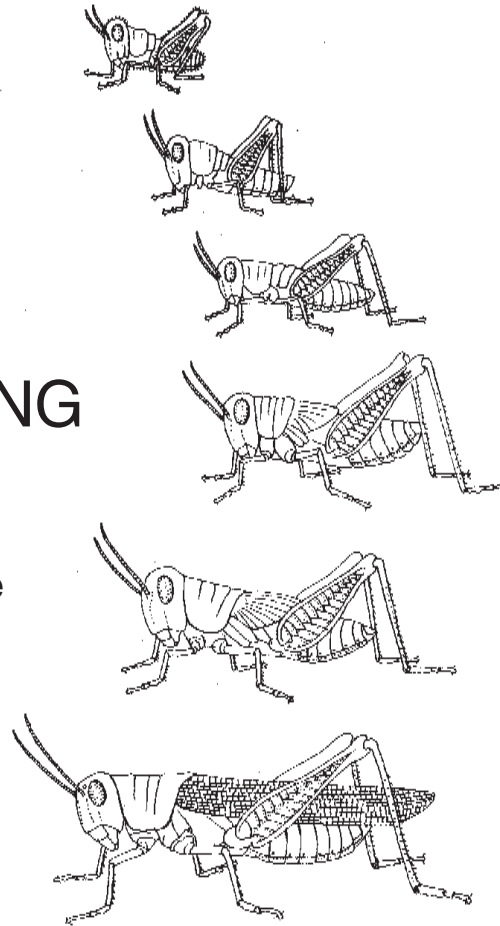
4 25 Nov 2000:

At what point does the banana peel stop becoming a banana peel? We cannot say that on a certain day it stopped being a banana peel. Actually it was always a banana peel in the process of becoming a non-banana peel.

The world  
consists of  
processes,  
not things.

# EVERYTHING CHANGES

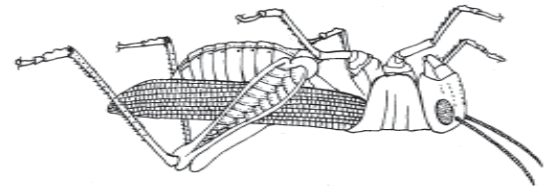
There are quantitative  
changes,



A GROWING GRASSHOPPER

and qualitative changes

the grasshopper dies





THINGS/PROCESSES  
ARE  
INTERCONNECTED  
AND  
INTERDEPENDENT

We cannot add or  
remove one thing in  
our environment  
without affecting other  
things.

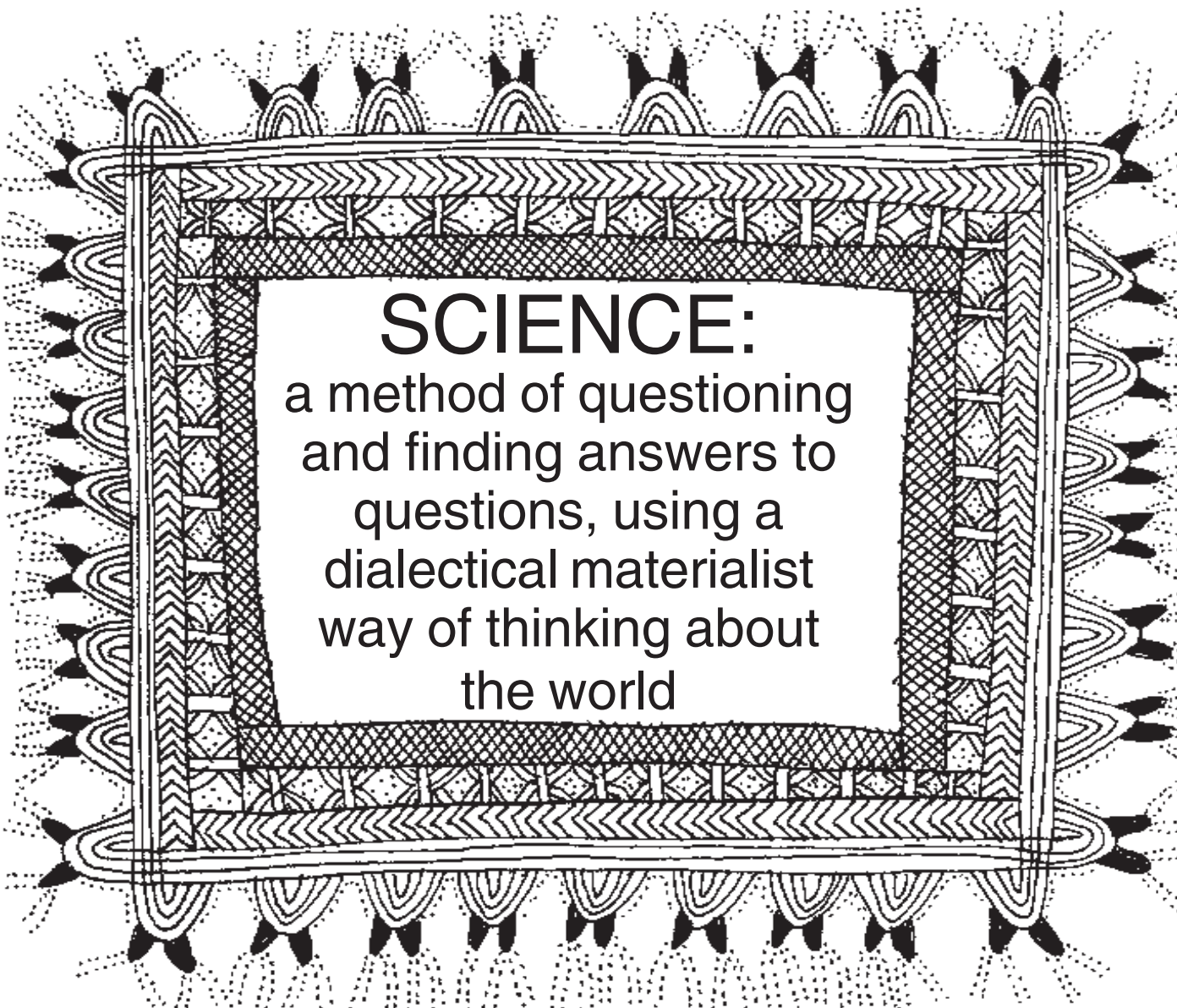
# EVERY NEW THING GETS REPLACED BY A NEWER THING

Death it can bring  
that kind of mushroom; and, of course,  
it's a pretty thing.

- Issa (1762-1826)







# SCIENCE:

a method of questioning  
and finding answers to  
questions, using a  
dialectical materialist  
way of thinking about  
the world

Now let's use DIALECTICAL MATERIALISM to understand the questions we asked at the beginning.

## 1. PLANTS GET BIG BY TAKING FOOD FROM THE SOIL THROUGH THEIR ROOTS.

### FALSE

Plants make their own food - they do not get it through their roots.

The bulk of a green plant is carbon, which comes from CO<sub>2</sub> in the air.

### BUT

In addition to air and sunlight, plants do need water and minerals to make food. They get these from the soil, through their roots.

The concept of 'food' is contradictory.





An animal's food is what it eats. An animal takes in food and breaks it down - digests it - in order to live and grow. It breaks down the complex substances and large molecules in its food (like carbohydrates and proteins) in order to get energy and make new complex molecules,

A plant also takes in substances in order to live and grow, but it takes in simple molecules (like  $\text{H}_2\text{O}$ ,  $\text{CO}_2$ , and salts) and uses energy from light to synthesize more complex molecules (like carbohydrates and proteins).

Usually when we think of 'food', we mean food for animals - the plants (and animals) that they eat. But we also think of food as something that is needed in order to live and grow - and for a plant, that would include the things it takes through its roots.

Processes are interconnected and interdependent.

## 2. BURNING IS A PROCESS IN WHICH MATTER IS DESTROYED.

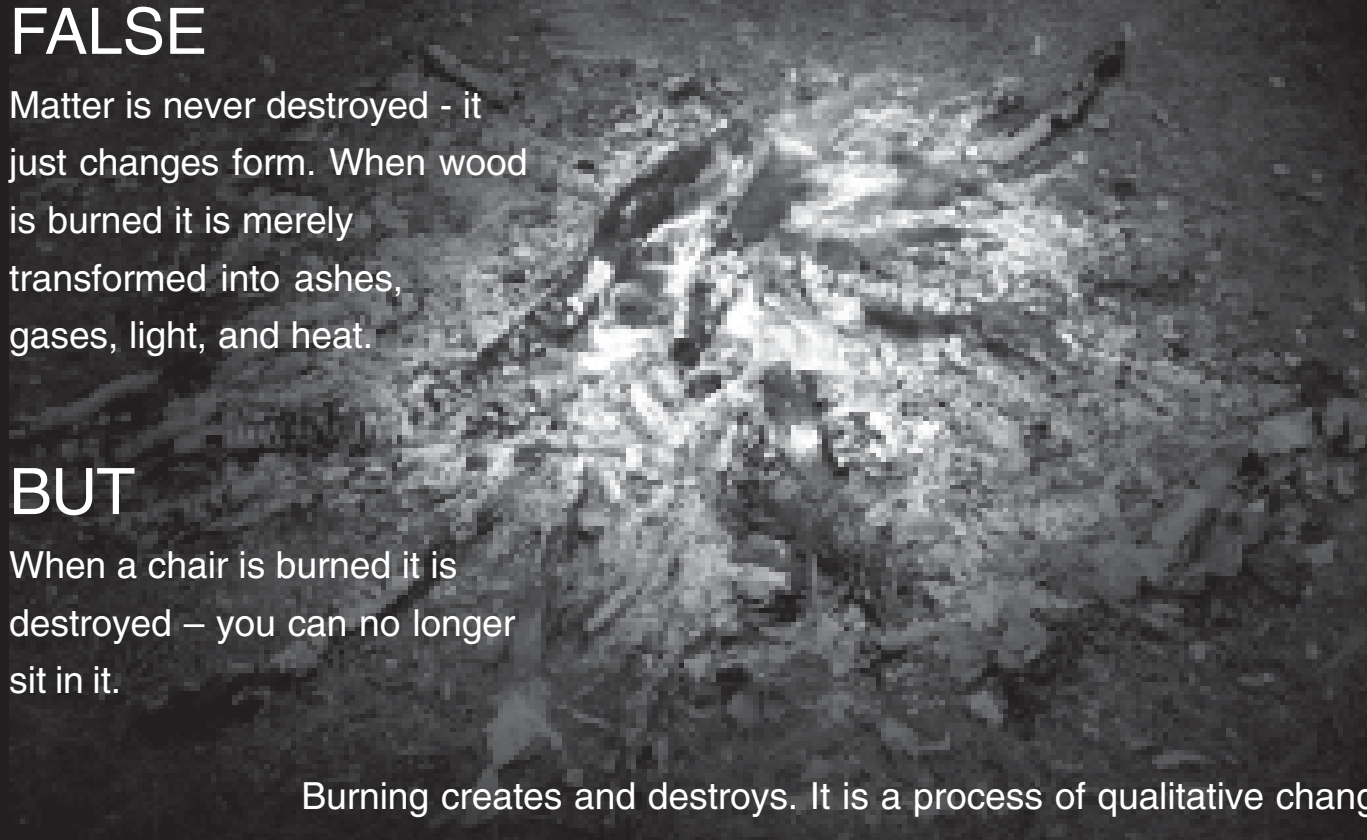
**FALSE**

Matter is never destroyed - it just changes form. When wood is burned it is merely transformed into ashes, gases, light, and heat.

**BUT**

When a chair is burned it is destroyed – you can no longer sit in it.

Burning creates and destroys. It is a process of qualitative change.



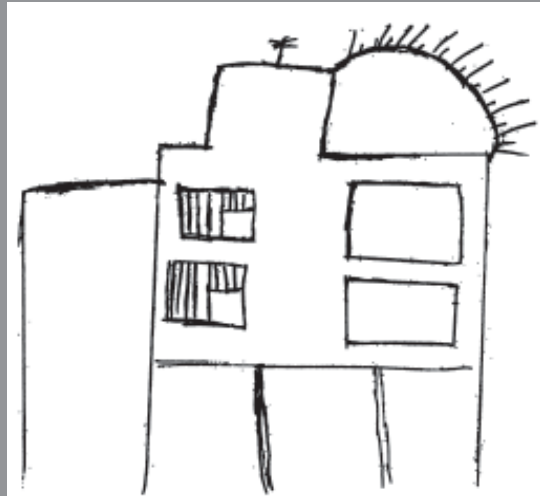
### 3. THE SUN RISES IN THE EAST.

## FALSE

The sun does not rise – the earth spins.

Depending on the time of year, we see the sunrise somewhere from NE to SE. If you go to the North Pole, where would you see the sun rise?

‘East’ is defined only in relation to something else.



There is a confusion between relative and absolute truth.

## 4. BLOOD IS RED.

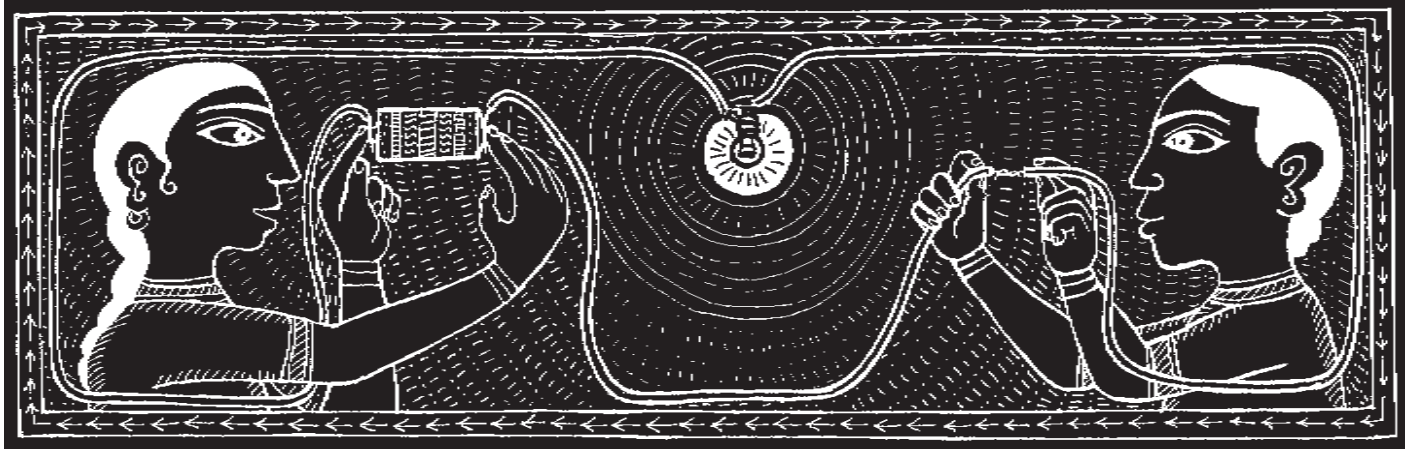
### FALSE

Blood is sometimes bluish and sometimes reddish, depending on how much oxygen it contains. When blood dries, it may look quite black. When we get cut, the blood we see is red because it is in contact with oxygen in the air.

What colour is blood when we see it through a microscope?

Things do not have fixed, unchanging characteristics.

## 5. ELECTRICAL CURRENT IS USED UP IN LIGHTING A BULB.



### FALSE

A bulb lights up when the electrical circuit is completed – what is required is a flow, not the consumption of a number of particles or some ‘amount’ of electricity.

### BUT

A cell does get used up if we leave a torch on too long.

And a bulb also uses up the money that it costs to pay for the current.

Electricity is a process, not a thing.

## 6. HEAVIER BODIES FALL FASTER THAN LIGHT ONES.

### FALSE

The speed of falling does not depend on the weight of the objects.

BUT

Light objects often have shapes that make them more easily slowed down by wind and friction with air.

Normally we do not drop objects in a vacuum.

It seems reasonable that the speed of falling depends on their weight (that is what Aristotle thought).

But if we base our reasoning on observations, we find that this is not true.

There are a number of opposing forces acting on objects.

## 7. CAVEMEN FOUGHT DINOSAURS.

### FALSE

Dinosaurs became extinct about 65 million years before humans evolved.

Large mammals could not evolve until large dinosaurs became extinct.

Things were not always as they are now. Nothing is fixed and unchanging. New forms of life evolve from old forms of life. Through science, we can understand evolution - the process of descent with modification.

Each new thing is replaced by a newer thing.

# TRUTH

## IS THERE AN ABSOLUTE TRUTH?

Truth is absolute, in the sense that there is a definite, objective reality, which in principle can be fully known.

Truth is relative, in the sense that the knowledge that we possess about reality is incomplete.

?



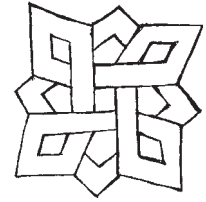
## FREEDOM

“Freedom does not consist in the dream of independence from natural laws, but in the knowledge of these laws, and in the possibility this gives of systematically making them work towards definite ends.

This holds good in relation both to the laws of external nature and to those which govern [our own] bodily and mental existence - two classes of laws which we [cannot really] separate.

Freedom of the will therefore means nothing but the capacity to make decisions with knowledge of the subject. Therefore the *freer* a man's judgment is in relation to a definite question, the greater is the *necessity* with which the content of this judgment will be determined...

Freedom therefore consists in the control over ourselves and over external nature, a control founded on knowledge of natural necessity.”



“Freedom is the recognition of necessity, and science is the cognition of necessity.”